International Journal of Mechanical and Production
Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 9, Issue 3, Jun 2019, 143-150

A HYBRID MCDM MODEL FOR SUPPLIER SELECTION IN SUPPLY CHAIN

SANATAN RATNA, ASHISH GOSWAMI, KUMAR ANAND,
ANAND KR. RAI & AKASH YADAV

Department of Mechanical Engineering, ASET, Amity University, Noida, Uttar Pradesh, India

ABSTRACT

Decision makers in SMEs across the world are in dilemma as a lot of suppliers with varying suitability are available in the market due to globalization and the liberalization of the Indian economy. The decision needs to be taken about the selection of the best supplier while keeping into account the various degrees of variations in the different criteria. This needs to be done to form an agile manufacturing environment. The current research work deals with the selection of the supplier based on six criteria among twenty-five suppliers. In order to achieve this, a hybrid MCDM model which consists of Grey Relational Analysis (GRA), Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). GRA is used to shortlist the most important criteria among a number of criteria available. AHP is used to give weightage to the various selected criteria. At the end, the TOPSIS method is used to select the best supplier among the available twenty-five suppliers. The hybrid GRAPH-TOP model hence developed is used to analyze the supply chain management of an SME (forging industry) in Delhi NCR.

KEYWORDS: SME, MCDM, AHP, GRA, TOPSIS, Agile manufacturing environment & Supply Chain Management

Received: Jan 22, 2019; **Accepted**: Feb 12, 2019; **Published**: Apr 13, 2019; **Paper Id**.: IJMPERDJUN201915

Original Article

INTRODUCTION

Decision makers in SMEs across the world are spoilt for choice as the number of alternatives lying in front of them is vast. The decision needs to be taken about the selection of the best supplier while keeping into account the various degrees of variations in the different criteria. The current research work deals with the selection of the supplier based on six criteria among twenty-five suppliers. In order to achieve this, a hybrid MCDM model which consists of Grey Relational Analysis (GRA), Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). GRA is used to shortlist the most important criteria among a number of criteria available. AHP is used to give weightage to the various selected criteria. At the end, the TOPSIS method is used to select the best supplier among the available twenty-five suppliers. The hybrid GRAPH-TOP model hence developed is used to analyze the supply chain management of an SME (forging industry) in Delhi NCR.

METHODOLOGY

The proposed methodology consists of ant integrated MCDM approach combining GRA, AHP &TOPSIS. The grey system theory was developed by Deng Julong of China in the year 1982. The concept of Grey system is basically a representation of an incomplete or uncertain information system as the grey color lies between black (no information) & white (all information). The method can convert a multi-response problem into a single response optimization problem by finding grey relation grades (GRG). AHP has been proved as a simple yet effective tool for multi-criteria decision making with plenty of applications reported in the fields of management science,

industrial engineering, social science, etc. the philosophy behind AHP is to use the perception of decision maker or a group of decision-makers to prioritize various components or criteria which when combined lead to a clear numerical value for each solution. The decision makers can make pairwise comparisons of these criteria towards fulfilling the goal more easily. Hence, AHP is used for finding the weightage by first decomposing the problem into criteria and sub-criteria, which affect the goal of the multi criteria problem. The final selection of the supplier is done by using the TOPSIS technique. It is an acronym for the technique for order preference by similarity to an ideal solution. As the name suggests, the basis of this tool is to find the solution for multi-criteria problem, which is nearest to the ideal solution.

The criteria used for supplier selection in SCM are listed below.

C1- Commitment to DeliverySchedule;C2- An ISO 9000 Certified Supplier ; C3- Past Supply Record ;

C4- Supply Capacity of Supplier;C5- Packing Done to the Raw Material by the Supplier;

C6- Geographical Position of the Supplier

A list of criteria is shown above with which the questionnaire for taking a survey from industry experts is prepared. Survey values from 25 industry experts (R1,R2,R3,R4….R25) who are involved in supplier selection is shown in table 1.

Table 1: Survey Values from 10 Industry Experts who are Involved in Supplier Selection

	C1	C2	C3	C4	C5	C6
R1	5	4	4	4	3	3
R2	5	5	3	3	2	4
R3	4	5	3	3	4	4
R4	3	5	5	3	4	2
R5	5	3	3	3	5	4
R6	4	4	3	4	4	2
R7	5	4	4	4	3	3
R8	3	3	4	3	3	3
R9	5	4	2	3	2	3
R10	4	4	4	3	3	5
R11	5	4	5	5	4	5
R12	4	5	5	4	5	5
R13	5	5	4	4	4	4
R14	5	5	5	5	4	4
R15	4	4	4	5	5	5
R16	5	5	5	4	4	4
R17	4	5	5	4	4	5
R18	5	5	4	3	3	5
R19	5	5	3	3	2	3
R20	5	3	2	5	4	4
R21	5	4	4	4	5	4
R22	5	5	5	5	4	4
R23	5	5	4	4	4	4
R24	5	4	4	5	5	5
R25	5	5	4	4	3	3

The table 2 below sows the difference with reference sequence values.

Table 2: Difference with Reference Sequence Values

	C1	C2	C3	C4	C5	C6
R1	0	1	1	1	2	2
R2	0	0	2	2	3	1
R3	1	0	2	2	1	1
R4	2	0	0	2	1	3
R5	0	2	2	2	0	1
R6	1	1	2	1	1	3
R7	0	1	1	1	2	2
R8	2	2	1	2	2	2
R9	0	1	3	2	3	2
R10	1	1	1	2	2	0
R11	0	1	0	0	1	0
R12	1	0	0	1	0	0
R13	0	0	1	1	1	1
R14	0	0	0	0	1	1
R15	1	1	1	0	0	0
R16	0	0	0	1	1	1
R17	1	0	0	1	1	0
R18	0	0	1	2	2	0
R19	0	0	2	2	3	2
R20	0	2	3	0	1	1
R21	0	1	1	1	0	1
R22	0	0	0	0	1	1
R23	0	0	1	1	1	1
R24	0	1	1	0	0	0
R25	0	0	1	1	2	2

The grey relational coefficient (GRC)is calculated now using the equation (1) below.

$$\xi i\ (K) = \frac{(\Delta min.+p\Delta max)}{(\Delta Xi(K)+p\Delta max)} \tag{1}$$

Here "p" is the distinguishing factor and is taken as 0.50. The tenacity of the peculiar coefficient is to increase/decrease the range of the GRC. Table 3 below shows the calculated grey relational grades.

Table 3: Calculated Grey Relational Coefficients

Responses from	C1	C2	C3	C4	C5	C6
R1	1	0.5	0.6	0.5	0.428571	0.428571
R2	1	1	0.428571429	0.333333333	0.333333	0.6
R3	0.5	1	0.428571429	0.333333333	0.6	0.6
R4	0.333333333	1	1	0.333333333	0.6	0.333333
R5	1	0.333333333	0.428571429	0.333333333	1	0.6
R6	0.5	0.5	0.428571429	0.5	0.6	0.333333
R7	1	0.5	0.6	0.5	0.428571	0.428571
R8	0.333333333	0.333333333	0.6	0.333333333	0.428571	0.428571
R9	1	0.5	0.333333333	0.333333333	0.333333	0.428571
R10	0.5	0.5	0.6	0.333333333	0.428571	1
R11	1	0.5	1	1	0.6	1
R12	0.5	1	1	0.5	1	1
R13	1	1	0.6	0.5	0.6	0.6
R14	1	1	1	1	0.6	0.6
R15	0.5	0.5	0.6	1	1	1
R16	1	1	1	0.5	0.6	0.6
R17	0.5	1	1	0.5	0.6	1

Table 3: Contd.,

R18	1	1	0.6	0.333333333	0.428571	1
R19	1	1	0.428571429	0.333333333	0.333333	0.428571
R20	1	0.333333333	0.333333333	1	0.6	0.6
R21	1	0.5	0.6	0.5	1	0.6
R22	1	1	1	1	0.6	0.6
R23	1	1	0.6	0.5	0.6	0.6
R24	1	0.5	0.6	1	1	1
R25	1	1	0.6	0.5	0.428571	0.428571

The next step is the calculation of grey relational grades (GRG) which is tabulated below in table no.4.

Table 4: Calculated Grey Relational Grades

Criteria	C1	C2	C3	C4	C5	C6
GRG	0.826666667	0.74	0.656380952	0.56	0.606857	0.649524

Here among the six criteria that are considered, four criteria are selected as prominent when compared to the other criteria. The criteria which are selected are C1 (Commitment to delivery schedule), C2 (An ISO 9000 certified supplier), C3 (Past supply record)& C6 (Geographical position of the supplier).

AHP-The AHP method is also termed as Eigen-vector method. It shows that the Eigen-vector corresponding to the biggest Eigen-value in the couple manner comparisons matrix gives the relatives priorities of the factor and preserve original among the alternatives. This shows that if an alternative is proportional to another one, its Eigen-vector component is greater than that to a different one. A vector of mass obtained from the couple wise comparison matrix reflects the relevant performance of other factors. In AHP, a multiple Criteria issue is built by hierarchically by parting down a problem into minor and minor consistent pieces. The excellent alternatives usually choose by manufacturing comparisons between alternatives with respect to others. The computational process of this approach has been shown as follows:-

Step 1: Determine the aim and the results attributes and construct the hierarchy structure model.

Step 2: Comparing the relevant strength of other attributes with respect to the goal or aim.

Step 3: Make the couple wise comparison matrix by using the below table no. 5.

Table 5: AHP Standard Preference Table

Preference Level	Numerical Value
Equally Preferred	1
Moderately Preferred	2
Strongly Preferred	3
Very Strongly Preferred	4
Extremely Preferred	5

The weightage of the criteria are calculated and tabulated below in table 6. The pairwise comparisons are done using Saatynine-point scale. The table 6 below lists the weightage of the four chosen criteria as calculated by the AHP method.

Table 6: Weightage of the Shortlisted Criteria Using AHP

Shortlisted Criteria	Weightage
C1	0.477687806
C2	0.263309545
C3	0.199513163
C6	0.059489486

The shortlisted criteria and their respective weightage are further passed t on to the TOPSIS technique for the final supplier selection.

TOPSIS-The final selection of the supplier is done by using the TOPSIS technique. It is an acronym for the technique for order preference by similarity to an ideal solution. As the name suggests, the basis of this tool is to find the solution for multi-criteria problem, which is nearest to the ideal solution. A decision matrix with the values obtained from a survey conducted in a company located in Delhi-NCR as shown in table 7 below.

Table 7: Weighted Normalized Decision Matrix

Supplier	C1	C2	C3	C6
S1	0.1029056441	0.0472941176	0.0397060550	0.0089591867
S2	0.1029056441	0.0591176471	0.0297795413	0.0119455823
S3	0.0823245153	0.0591176471	0.0297795413	0.0119455823
S4	0.0617433865	0.0591176471	0.0496325688	0.0059727912
S5	0.1029056441	0.0354705882	0.0297795413	0.0119455823
S6	0.0823245153	0.0472941176	0.0297795413	0.0059727912
S7	0.1029056441	0.0472941176	0.0397060550	0.0089591867
S8	0.0617433865	0.0354705882	0.0397060550	0.0089591867
S9	0.1029056441	0.0472941176	0.0198530275	0.0089591867
S10	0.0823245153	0.0472941176	0.0397060550	0.0149319779
S11	0.1029056441	0.0472941176	0.0496325688	0.0149319779
S12	0.0823245153	0.0591176471	0.0496325688	0.0149319779
S13	0.1029056441	0.0591176471	0.0397060550	0.0119455823
S14	0.1029056441	0.0591176471	0.0496325688	0.0119455823
S15	0.0823245153	0.0472941176	0.0397060550	0.0149319779
S16	0.1029056441	0.0591176471	0.0496325688	0.0119455823
S17	0.0823245153	0.0591176471	0.0496325688	0.0149319779
S18	0.1029056441	0.0591176471	0.0397060550	0.0149319779
S19	0.1029056441	0.0591176471	0.0297795413	0.0089591867
S20	0.1029056441	0.0354705882	0.0198530275	0.0119455823
S21	0.1029056441	0.0472941176	0.0397060550	0.0119455823
S22	0.1029056441	0.0591176471	0.0496325688	0.0119455823
S23	0.1029056441	0.0591176471	0.0397060550	0.0119455823
S24	0.1029056441	0.0472941176	0.0397060550	0.0149319779
S25	0.1029056441	0.0591176471	0.0397060550	0.0089591867

The table 8 below shows the positive ideal solution and negative ideal solutions.

Table 8: Ideal Best and Ideal Worst Solution Table

	C1	C2	C3	C6
Vj+	0.061743	0.035470588	0.019853028	0.014931978
Vj-	0.102906	0.059117647	0.049632569	0.005972791

The next step is to calculate the Euclidean distance from the ideal best to the ideal worst using the equations 2 & 3 below.

$$S_i^+ = \left[\sum_{j=1}^{m}\left(V_{ij} - V_j^+\right)^2\right]^{0.5} \tag{2}$$

$$S_i^- = \left[\sum_{j=1}^{m}\left(V_{ij} - V_j^-\right)^2\right]^{0.5} \tag{3}$$

Finally the performance score of all the 25 suppliers (S1, S2, S3…S25) are calculated using the equation 4 below.

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \tag{4}$$

The calculated values of S_i^+,S_i^- and the performance score i.e., $P_i$are tabulated below in the table 9.

Table 9: Calculation of Performance Score Pi and Rank

Suppliers	Si+	Si-	Si+ + Si-	Pi	Rank
S1	0.0156	0.04769	0.06329	0.753515563	8
S2	0.02089	0.04859	0.069480132	0.699338509	13
S3	0.02923	0.033019	0.062248728	0.530432172	18
S4	0.041206	0.039068	0.080273525	0.486680071	20
S5	0.031448	0.042448	0.073895821	0.574427895	16
S6	0.03107	0.027243	0.058313299	0.467188433	21
S7	0.01585	0.047581	0.063431257	0.750123193	9
S8	0.0494	0.020732	0.070132026	0.29561425	22
S9	0.03175	0.043242	0.07499157	0.576619078	15
S10	0.027243	0.030944	0.0581871	0.531803439	17
S11	0.014835	0.052163	0.066998015	0.778575531	7
S12	0.022447	0.043239	0.065685909	0.658267649	14
S13	0.011585	0.051542	0.063127292	0.816481912	5
S14	0.005973	0.056119	0.062091502	0.903803261	2
S15	0.027243	0.030944	0.0581871	0.531803439	17
S16	0.005973	0.056119	0.062091502	0.903803261	2
S17	0.022447	0.043239	0.065685909	0.658267649	14
S18	0.013372	0.051456	0.064827703	0.793730158	6
S19	0.020076	0.048865	0.068940676	0.708793108	12
S20	0.038493	0.041271	0.079763835	0.517412873	19
S21	0.016553	0.047299	0.063852383	0.740759568	10
S22	0.005973	0.056119	0.062091293	0.903806299	1
S23	0.011585	0.051542	0.063127193	0.816483201	4
S24	0.017849	0.047205	0.065054221	0.72562381	11
S25	0.010366	0.051801	0.062167207	0.83325592	3

It is very much clear and evident from the table 9 above, that the “supplier 22”is the closest to the positively ideal solution and at the same time, farthest from the negative ideal solution. Hence, “Supplier 22” is the best supplier amongst the other alternatives mentioned.

CONCLUSIONS

In the current research work, an amalgam or a hybrid of various problem-solving tools was used. Consequentially, the approach developed was a hybrid GRAPH-TOP model which aimed at solving the problem of selection the best supplier among twenty-five available suppliers. The complete problem was solved at three stages. In the beginning, the list of criteria was cut down by selecting only the four most important criteria among the six criteria. This was done using Grey Relation Analysis (GRA). Next, the shortlisted criteria were given weightage using AHP technique. Last but not least, the final supplier-selection was done using the TOPSIS method. The GRAPHTOP was used to perform an analysis on small and medium scale industries in the selection of suppliers and was applied to a small scale industry in Delhi-NCR. The GRAPH-TOP analysis shows that the "supplier 22" is closer to the positive ideal solution which is evident that it is the ideal option. The current research work also emphasizes that the MCDM GRAPH-TOP heuristics can be applied successfully in different industries too for supplier selection.

REFERENCES

1. *Adalı, E., Işık, A & Kundakcı, K. (2016). An alternative approach based on Fuzzy PROMETHEE method for the supplier selection problem.Uncertain Supply Chain Management, 4(3), 183-194.*
2. *Banaeian, N., Mobli, H., Fahimnia, B., Nielsen, I. E., & Omid, M. (2018). Green supplier selection using fuzzy group decision making methods: A case study from the agri-food industry. Computers & Operations Research, 89, 337-347.*
3. *Chai, J., Liu, J. N., & Ngai, E. W. (2013). Application of decision-making techniques in supplierselection: A systematic review of literature. Expert Systems with Applications, 40(10), 3872-3885.*
4. *Prasath, K. A., & Johnson, R. D. J. Scrutiny of Machine Assignment in Various Intra-Cell Layout in Cellular Manufacturing using Automation Studios.*
5. *Galankashi, M. R., Helmi, S. A., & Hashemzahi, P. (2016). Supplier selection in automobile industry: A mixed balanced scorecard–fuzzy AHP approach. Alexandria Engineering Journal, 55(1), 93-100.*
6. *Hamdan, S., & Cheaitou, A. (2017). Supplier selection and order allocation with green criteria: An MCDM and multi-objective optimization approach. Computers & Operations Research, 81, 282-304.*